

## Diabetic foot ulceration: The impact of oedema

**Keywords:** Diabetic foot ulceration, lower limb oedema, compression therapy, lower limb ulceration.

### Introduction

The impact of diabetic foot disease on people with diabetes is profound and is associated with disability, amputation and premature death (National Diabetes Foot Care Audit Report, 2016). Diabetic foot ulceration (DFU) is common in people with diabetes, with around 10% of this group having a foot ulceration at some point in their lifetime (NICE, 2015). There are significant costs to the NHS ~~in for~~ caring for patients with DFU; with annual costs estimated at £650 million; equating to £1 in every £150 spent by the NHS (Kerr, 2012). Delayed healing is a common factor with DFU; Guest, Fuller, and Vowden (2017) report that only 35% of patients with DFU will heal within a 12-month period.

Chronic oedema affects over 100,000 people in the United Kingdom (Lewis & Morgan, 2008), with the prevalence of lower leg chronic oedema increasing year-on-year as a result of an aging population and rising obesity rates. Oedema in isolation is frequently recognised but often not treated (Atkin, 2014). However, many practitioners are aware of the importance of addressing the oedema to facilitate leg ulcer healing in patients with leg ulceration (Lymphoedema Framework, 2006). A cornerstone to the management of oedema is compression therapy, which is known to reduce oedema in a number of ways; including the direct application of pressure to ensure that less fluid is allowed to leak out of the capillary vessels whilst simultaneously encouraging more fluid to be reabsorbed into the venous and lymphatic systems (Wounds International, 2013).

The reduction and management of oedema in the lower limbs is known to improve healing rates in lower limb ulceration (Wounds International, 2013). ~~In patients with diabetes the regulation of blood flow is impaired by either arterial disease or diabetic neuropathy. These changes in blood flow result in loss of sympathetic vascular tone which is linked to the inability of the body to effectively vasoconstrict the capillary vessels, leading to hyperperfusion and a high hydrostatic load, which in terms leads to oedema of the lower limbs and feet~~ (Ho, Leigh, & Tsui, 2013).

Where patients have evidence of both DFU and lower limb oedema, compression therapy is not always considered. Oedema can affect all or part of the lower limb; the toes, the dorsum of foot, ankle or gaiter region can be affected in isolation but often is present throughout the whole of the lower limb.

The presence of oedema in patients with DFU has been found to be linked with poorer outcomes: lower limb ~~oedema is more common in patients who require amputation, or in those who~~

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**Commented [A3]:** Please consider re-wording, as currently it does not read well. Do you mean atherosclerotic changes and autonomic neuropathy? it doesn't happen in every patient with Diabetes but reads as if it does. The next sentence reads as if atherosclerotic changes result in loss of sympathetic vascular tone which I do not think is correct, please can you check this is accurate.

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subsequently die; compared to patients who heal (Apelqvist, Larsson, & Agardh, 1990). This is thought to be due to the complexities of these patients often having concomitant medical conditions such as renal failure, heart failure and being generally of poor health.

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This article will deliver an overview of the important aspects of DFU management in combination with lower limb oedema and will provide details of results of a local audit investigating the incidence of lower limb oedema in patients with DFU.

### Assessment

The NICE guidelines for the management of patients with DFU (NICE, 2015) advocates neurovascular screening of every patient every time a foot problem arises. For those who develop an active foot ulcer, a referral should be made immediately to the diabetes foot specialist team. If specialist teams are considering oedema reduction as part of management, the following underlying conditions need to be explored as they can influence types of oedema and treatment options: diabetes control; heart failure; ~~control~~; kidney disease/failure; recent surgery; Deep Vein Thrombosis (DVT); Charcot arthropathy; lifestyle factors, i.e. obesity, immobility, concordance (NICE, 2015; Wounds UK, 2016).

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Vascular assessment is imperative if compression therapy is to be considered for oedema reduction to ensure the patient has no evidence of Peripheral Arterial Disease (PAD) where compression therapy may be contradicted (NICE, 2012). Palpating pedal pulses and listening to arterial sounds with a hand-held Doppler is a simple test which will provide information of an individual's vascular status. A biphasic or triphasic signal would suggest that there is no evidence of occlusive or stenotic arterial disease, whereas a monophasic signal suggests the presence of PAD. The calculation of the Ankle Brachial Pressure Index (ABPI) is useful tool in establishing whether a patient has any evidence of PAD and therefore in assessing their suitability of compression therapy. However, in patients with diabetes caution is required when interpreting the ABPI, as diabetes is known to increase the presence of medial arterial wall calcification, which can lead to incompressible arteries or a falsely elevated ABPI result (Al-Qaisi, Nott, King, & Kaddoura, 2009). However, it is important to remember that an elevated ABPI does not preclude patients from having compression therapy, in these cases the arterial supply need to be assessed using other methods such as pulse palpation, arterial duplex scan, magnetic resource angiograms or through onward referral to specialist services.

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Where there is evidence of severe oedema, Doppler and ABPI assessment can be challenging, simply due to the size of the lower leg. In these cases larger size blood pressure cuffs and Doppler probes designed to look deeper into tissue (5 Mhz) may be required. In cases where arterial wall calcification is present or where ABPI cannot be calculated, the use of Toe Brachial Pressure Index (TBPI) may be

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~~useful~~~~required~~, and this is argued to be more reliable in diabetic patients, due to the distal arteries being less likely to be affected by arterial wall calcification (Aiello et al., 2014).

### Compression therapy

Compression therapy should only be instigated by a professional with the appropriate underlying skills and competency in lower limb assessment/compression therapy. There are a number of compression systems available. These include: compression hosiery (treatment hosiery/ulcer kits, toe caps, preventative hosiery); compression wrap systems; or multi-component compression bandaging.

#### Compression Hosiery kits

Treatment hosiery kits are designed to apply a graduated compression value of 40 mmHg at that ankle. Hosiery kits have been proven to be as equally effective at healing venous leg ulcers compared to multi-component bandages (Ashby, Gabe, Ali, & Adderley, 2014). Furthermore, hosiery kits have additional advantages over multi-component bandages: they are less expensive; are less bulky and therefore do not restrict patients choice of footwear or clothing; offer guaranteed levels of compression, which is not practitioner dependent; allow patients to self-care; and reduce nursing time as they are quicker to apply (Atkin, 2015). However, they are not suitable where the patient has irregular limb shapes, gross amount of oedema or if the patient has heavily exuding wounds where the exudate is not contained within the dressings (Wounds UK, 2016). Where toe oedema is present, toe caps, a type of glove for the foot, can offer an advantage at reducing oedema. They provide an alternative to toe bandaging and can be used on top of dressings (Elwell & Wig, 2015).

#### Compression Wraps

~~For some patients,~~ compression wraps are a valuable alternative to deliver sustained compression.

Compression wraps systems are adjustable devices which consist of low elastic material sections that wrap across the limb and are secured with hook and loop fasteners. They are designed for self-application over the short- or long-term, enabling the patient or carer to apply or adjust the device as required, in their own setting. It is important to remember that where ulceration is present, clinicians should aim to treat their patients with 'full strength' compression of 40 mmHg at the ankle wherever possible to optimise the healing.

~~However, the complexity of the foot ulcerations in patients with diabetes means that factors such as neuropathy, neuropathic pain, arterial disease or foot deformity may make full strength compression unsuitable for the individual patient.~~ The advantage of the compression wrap system is that it may be adjusted to meet comfort levels, can be easily adjusted as

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**Commented [A19]:** Compression hosiery, wraps and bandages are not clearly separated out and may be confusing for the uninitiated, consider making a point of separating the various methods with a run-in line, e.g. compared to hosiery kits and multi bandage systems compression wraps....

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I like it as adds to the many factors that need to be considered before compression is commenced? - maybe it should be moved to lower down?

limb volume ~~is -reduced~~ ~~reduction~~, and allows self-care. All of these factors can facilitate concordance with compression. The separate leg and foot pieces which can be adjusted independently of one another can hold advantages, as they allow modification to accommodate specific foot problems.

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The compression wrap systems are designed to apply a graduated compression of 40 mmHg at the ankle, and some systems do have built-in pressure measurements. However, not all compression wraps systems are able to guarantee the level of compression applied, as the amount of compression delivered is dependent on the application technique. Compression wrap systems can hold advantages in patients where limb volume will reduce quickly, where there is limb deformity or where the patient wishes to self-care; they are not suitable for patients who have heavily exuding wounds where the exudate are not controlled within the dressing (Wounds UK, 2016).

#### Multicomponent Bandaging

Multi-component bandaging is required where patients have gross oedema/congestion, irregular shaped limbs and/or foot deformities, or where the exudate is not contained within the dressings; due to the adaptability of bandages and the ability to reshape the limb and absorb a degree of exudate.

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Bandage systems have been proven to improve venous and lymphatic return (O'Meara, Cullum, Nelson, & Dumville, 2012). However, the application of compression bandaging requires a high level of skill and can only be applied by an appropriately trained competent professional. In cases where interdigital ulceration or gross toe oedema is present, ~~lymphoedema toe caps or further specialist bandaging techniques, including toe bandaging, stump techniques or stirrup bandaging may be required~~ (Atkin & Sykes, 2015). There are, however, some disadvantages for the patient in using compression bandages which can affect their concordance with the compression therapy, as they can be bulky and restrict choice of clothing and footwear (Miller et al., 2011). Additionally, compression bandaging has been shown to affect the ankle range of movement, and therefore may increase the risk of falling in the elderly patient (Atkin et al., 2016).

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**Commented [A26]:** Can lymphoedema toe caps be used with multilayer bandaging to negate this?

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~~The choice of which compression system should be used is based on a number of factors, and should not solely be influenced by clinical effectiveness but important factors such as: patient lifestyle; clinical presentation of the wound and the limb; patient choice; practitioners' own knowledge and skills; and treatment costs. These factors should all have a role in decision making~~ (Moffatt, Kommala, Dourdin, & Choe, 2009). However, the complexity of the foot ulcerations in patients with diabetes means that factors such as neuropathy, neuropathic pain, arterial disease or foot deformity need to be considered prior to the application of compression. The choice of which compression system should be used is based on a number of factors, and should not solely be influenced by clinical effectiveness but

important factors such as: patient lifestyle; clinical presentation of the wound and the limb; patient choice; practitioners' own knowledge and skills; and treatment costs. These factors should all have a role in decision making (Moffatt et al., 2009) ~~may make full strength compression unsuitable for the individual patient.~~

### Wound care

Wound bed preparation is an important aspect to promote healing in patients with diabetic foot ulceration. Dressings should be selected according to the type of tissue present, presence of infection/biofilm, the levels of exudate and the overall treatment aims. Where lymphorrhea is present (lymph fluid exuding onto the surface of the skin), appropriate compression therapy is key to effectively reducing and managing the levels of exudate. The amount of exudate can significantly impact on patient quality of life resulting in wet clothing, footwear and bedding. If left unmanaged, lymphoedema can cause moisture damage and maceration to the skin, leading to increased areas of ulceration. In cases where exudate levels are often high, super absorbent dressing can aid exudate management, and the use of skin protectors can help protect the peri-wound area from further excoriation or moisture. Effective management of high exudate levels, especially lymphorrhea presents significant challenges to practitioners. It is vital that appropriate treatment is commenced immediately to prevent further skin breakdown and to reduce the risk of infection (Todd, Lay-Flurrie, & Drake, 2017).

### Skin care

Skin care is an essential part to both the management of patients with lower limb oedema and diabetic foot ulceration. Healthy hydrated intact skin provides the most effective barrier to reduce the risk of infection in an already immunocompromised patient. Skin care should be embedded in patients' everyday practice, with patients being encouraged to build a daily routine including inspection of the skin, careful washing and use of emollients (McIntosh & Green, 2009).

### Lifestyle advice

Patients should be encouraged to elevate their legs for short periods during the day and to sleep in bed at night. Sleeping in a chair should be discouraged - even in reclining chairs. Periods of elevation of the lower limbs aids venous and lymphatic return. The benefits of a healthy balanced diet should be discussed, and if the patient is obese, interventions to aid weight loss should be encouraged. Reduction in weight will aid both diabetes control and oedema reduction as obesity impedes lymphatic flow (McIntosh & Green, 2009; Wing et al., 2011).

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I like it as adds to the many factors that need to be considered before compression is commenced? - maybe it should be moved to lower down?

## Clinical Audit

An audit was carried out aiming to document the prevalence of lower limb oedema in patients with either type 1 or type 2 diabetes in an area of South Devon. The patients had either an active foot ulcer or a recent history of ulceration, and therefore classified as ulcerated or high risk respectively. The audit took place within a Community NHS Trust and run over a period of 12 weeks. Data from 7 podiatry clinics was collected and a total of 80 patients, selected at random, were included in the audit.

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(otherwise it reads as if both groups are high risk )

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Each clinic was booked by other members of the Podiatry team and included a mix of both diabetic and non-diabetic foot ulcers and diabetic patients classed as high risk. The auditing podiatrist then screened patients to see whether they were suitable for the audit. Although individuals often returned to the clinics on a weekly basis for treatment, each individual was only counted once. The total number of patients attending the podiatry clinics over the audited time frame was 120.

If the patient had an active foot ulcer, the audit was also used to document the prevalence of evidence of lower limb oedema or lymphorrhea. For each patient, a series of observations were undertaken, including:

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- Assessment of oedema – visual observation of whether oedema was present, palpation of the skin for signs of pitting oedema and assessment using the ‘Stemmer’s sign’. Stemmer's sign is a clinical sign, indicating the presence of lymphedema. It is positive if the skin of the forefoot cannot be pinched and lifted. Testing for Stemmer's sign consists of trying to lift the skin over the second toe, using the thumb and index finger in a pinching movement.
- The location of any ulceration and whether the wound occurred on or below the level of the malleoli.
- Where active foot ulcer was present the evidence of lymphorrhea was recorded, using the definition of ‘water-like fluid accumulating on the base of the wound/running or dripping from the wound after drying/blotting wound with sterile gauze swab’.
- If oedema was present, individual factors known to influence oedema and cross referencing with the patients’ medical history, were recorded using a check list (Table.1.)
- Whether each patient was using any kind of compression therapy or diuretics to help manage their oedema.

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*Table. 1. Checklist used and definitions used to describe co-factors which are present in each individual identified with lower limb oedema.*

Venous insufficiency	Visual signs/skin changes associated with venous insufficiency: ankle flare, varicose eczema, haemosiderin staining, atrophie blanche, varicose veins etc.
Peripheral neuropathy	Patient scored 4/5 or less in 10g monofilament test on one or both feet.
Obesity	BMI of greater than 30 kg/m <sup>2</sup>
Heart	Has the patient been diagnosed with heart failure?
Lung	Has the patient been diagnosed with asthma or COPD?
Liver	Has the patient been diagnosed with liver disease. Check Liver Function Test.
Kidney	Has the patient been diagnosed with Chronic Kidney Disease? Review patient's eGFR.
Mobility	Ask patient about activity levels.

## Results

A total of 80 diabetic patients were included in the audit. Their ages ranged from 44 to 98 years (median age=76 years). Table 2 shows the total number of patients observed to have diabetic foot ulcer and/or lower limb oedema in the total sample. The table further reports the number of patients who presented with both conditions (to potentially explore whether this could be an additional risk factor in the diabetic foot); the total number of patients from the sample group observed to have a diabetic foot ulcer and lymphorrhea; and the number of patients presenting with oedema who were prescribed an intervention to help manage the oedema.

*Table 2 Audit data indicating numbers of patients with diabetic foot ulceration (with associated lymphorrhea) and/or lower limb oedema (with use of compression therapy or medication)*

Condition	Frequency (valid %)
Diabetes	80 (100%)
Diabetic Foot Ulceration	
Yes	38 (47.5%)
Presenting with lymphorrhea	7 (8.75%)
Not presenting with lymphorrhea	31 (38.75%)
No	42 (52.5%)
Lower Limb Oedema	
Yes	44 (55.0%)
Using compression therapy <sup>1</sup>	3 (3.75%)
Using diuretic medication	16 (20.0%)
Not using compression therapy or diuretic medication	25 (31.25%)
No	36 (45.0%)
Multiple conditions	
Both Diabetic Foot Ulceration <b>and</b> Lower Limb Oedema	21 (26.25%)
Diabetic Foot Ulceration only	17 (21.25%)
Lower Limb Oedema only	23 (28.75%)
Neither condition	19 (23.75%)

<sup>1</sup>including bandaging, hosiery or wrap systems

Table 2 indicates that a substantial minority (19 out of 44; 43.2%) of diabetic patients presenting with oedema are prescribed an intervention to help manage the oedema; with diuretic medication amounting to the majority of such interventions. Hence interventions are being considered in this group of patients; however, compression therapy is not being widely used (only 3 out of 44 (6.8%) oedema patients are given compression therapy). This raises the issue of why this treatment is not widely given in those patients with diabetes, especially in those with an adequate vascular supply.

Table 2 also indicates that lymphorrhea is a fairly uncommon, but not unknown, co-morbidity amongst patients with lower limb oedema. The seven patients in this cohort who also presented with lymphorrhea represented 18.4% of the 38 patients with lower limb oedema; suggesting that the concomitant presence of lymphorrhea in patients with lower limb oedema is something that those treating diabetic foot ulcers need to be aware of, and have a plan for its management.

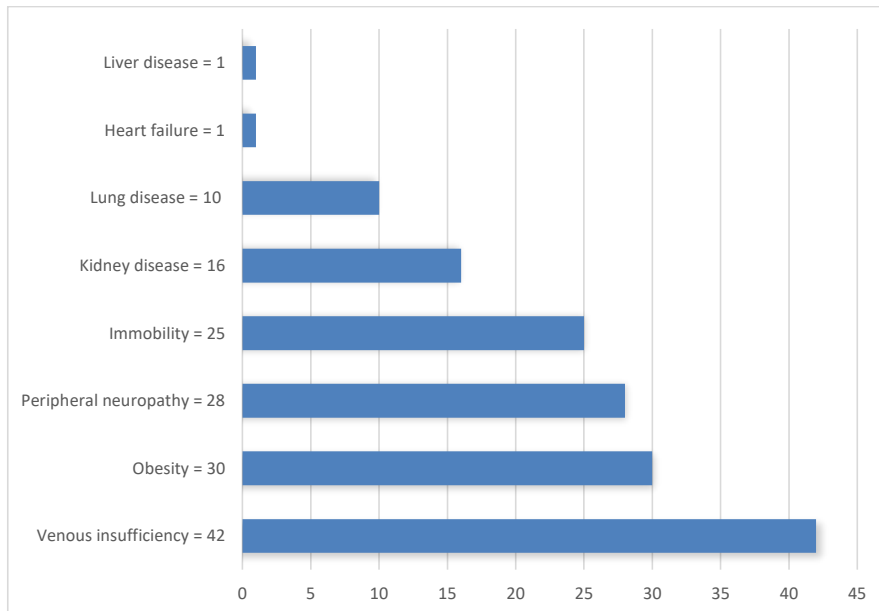
Table 2 further reports the number of patients who presented with both conditions; demonstrating that lower limb oedema **may commonly** co-exists in those with diabetes and diabetic foot ulcers.

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The prevalence of the common factors influencing lower limb oedema in the sample group was assessed, to explore whether the disease process of diabetes, which can be responsible for complications such as peripheral neuropathy and renal impairment, directly influences lower limb oedema in this group of patients; or whether other factors co-exist which potentially could also be taken into account when managing this group of patients. Venous insufficiency was the most commonly occurring co-morbidity; being present in over half of assessed patients, with significant numbers of patients also found have obesity and/or peripheral neuropathy. All co-factors associated with presence of lower limb oedema are summarised graphically in Figure 1.

Figure 1: co-factors associated with presence of lower limb oedema





## Summary

Diabetic foot ulcers are complex, and a multidisciplinary approach to management is essential. It is widely accepted that there are many factors which impact healing of diabetic foot ulceration: peripheral arterial disease, peripheral neuropathy, renal disease and foot deformity; but this audit highlights that oedema also needs to be considered and appropriately managed. The rising prevalence of the elderly- and lifestyle-related chronic illness means that chronic lower limb oedema is encountered by many practitioners (Todd et al., 2017). Obesity and sedentary lifestyle, which are common factors in patients with diabetes, seriously impact on the development and progression of chronic oedema.

Chronic oedema can have devastating physical and psychological effect on the patient. The extra weight of the swollen limb can affect gait and mobility, and cause pain in the surrounding joints and muscles (Todd et al., 2017). This extra weight of the limb will impact the healing of the diabetic foot ulceration and the ability to reduce the pressure load. Compression therapy is the mainstay in oedema management, and with the correct specialist team involvement, regular monitoring and a treatment plan tailored to each individual patient, this practice is safe in patients with diabetes and adequate peripheral arterial circulation (SIGN 120, 2010; Wounds UK 2016). Treatment of lower limb oedema in patients with DFU can improve outcomes for patients with DFU (Ho et al., 2013). Therefore, it is important that all practitioners managing patients with DFU are aware of the

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**Commented [A35]:** really great article, I enjoyed reading it. We have just had a Podiatrist trained in compression therapy, I wonder if it might be worth discussing the dissemination of this skill to clinicians who manage diabetic foot ulceration, but are not traditionally involved in the management of oedema. Also, could you consider discussing what sites would most benefit from compression therapy, I know you have mentioned the toes but is it useful for the dorsum and plantar but not the outer borders? It would genuinely be useful to my own practice to have this explored in the article!

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importance of oedema management and wherever possible undertake education and training in the art of compression therapy.

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